2.21 Traffic Signals

2.21.1 *General*

The Design-Builder shall perform all Work necessary to meet the Contract requirements for the traffic signal systems. The traffic signal systems for the Project shall include, at a minimum, the following:

- Signal standards and mast arms
- Luminaires on signal standards
- Foundations
- Vehicle heads
- Accessible pedestrian signals
- Accessible pedestrian pushbutton assemblies
- Vehicle detection
- Emergency vehicle preemption detectors
- Terminal cabinets
- Junction boxes
- Conduits and wirings
- Temporary vehicle detection system
- Temporary traffic signal system
- Uninterruptable Power Supply (UPS) system
- Traffic signal control cabinet and associated equipment
- Signal interconnect

The Design-Builder shall install electrical services or utilize existing services to provide power for all signal systems, in accordance with the Contract.

The Design-Builder shall maintain existing traffic signal systems during construction in accordance with Section 2.29, *Maintenance During Construction*.

2.21.1.1 *Forward Compatibility*

determined during phase 1

2.21.2 *Mandatory Standards*

The following is a list of Mandatory Standards that shall be followed for all design and construction related to this Section as referenced in Section 2.2, *Mandatory Standards*.

1. Special Provisions (Appendix 4)
2. WSDOT ***$$1$$*** *Electrical Special Provisions* (Appendix 4)
3. WSDOT ***$$2$$*** *Electrical Equipment Specifications* (Appendix 4)

4. WSDOT *Construction Requirements for Light and Signal Standard Foundations Using Drilled Shaft Construction and Permanent Casing* (Appendix 4)
5. Standard Specifications M 41-10 (Appendix 4)
6. WSDOT ***$$3$$*** *Current Practices in Electrical Design* (Appendix 4)
7. WSDOT ***$$4$$*** *Standard Signal Details* (Appendix 4)
8. WSDOT *Design Manual* M 22-01 (Appendix 4)
9. Standard Plans M 21-01 (Appendix 4).
10. WSDOT *Traffic Manual* M 51-02 (Appendix 4)
11. *Washington State Modifications to the Manual on Uniform Traffic Control Devices* (WAC 468-95) (Appendix 4)
12. WSDOT *Materials Manual* M 46-01 (Appendix 4)
13. WSDOT *Construction Manual* M 41-01 (Appendix 4)
14. *NFPA 70: National Electrical Code (NEC)*, 2008
15. *IESNA American National Standard Practice for Roadway Lighting (ANSI/IES RP-8-00)*
16. WSDOT *Plans Preparation Manual* M 22-31 (Appendix 4)
17. WSDOT *Maintenance Manual* M 51-01 (Appendix 4)
18. *FHWA Manual on Uniform Traffic Control Devices for Streets and Highways*, 2009 Edition with Revisions 1 and 2 dated May 2012 (Appendix 4)
19. WSDOT *Signal Turn-On Requirements* (Appendix 4)
20. *AASHTO A Policy on Geometric Design of Highways and Streets*
21. WSDOT *Bridge Design Manual (LRFD)* M23-50 (Appendix 4)
22. *AASHTO Roadside Design Guide*
23. *Transportation Research Board Highway Capacity Manual*

2.21.3 *Design Requirements*

The Design-Builder shall perform all Work necessary to design and construct a permanent traffic or pedestrian signal system as follows:

- *** determined during phase 1***

The new traffic signal systems shall meet the following performance requirements:

- Optimize traffic flow and minimize delay
- Interconnect with signalized intersections on the main line and arterial roads within a mile of the new traffic signal system
- Accommodate pedestrians

- Function safely
- *** determined during phase 1***

2.21.3.1 *Operational Analysis Software*

Refer to Section 2.21, *Traffic Operations*, for software requirements pertaining to traffic signal operations modelling.

*** determined during phase 1***

2.21.3.2 *Design Documentation*

The Design-Builder shall provide all documents and information required for the Design Documentation Package.

2.21.3.3 *Foundations*

The Design-Builder shall conduct a soil investigation for each signal standard location. Foundations for signal standards shall require soil analysis and investigation to determine impacts to signal standard foundation design, including the lateral bearing pressure, friction angle, and water table. All underground Utilities within 5 feet of the proposed signal foundations shall be located by potholing.

Where Standard Plan foundations cannot be used, foundations shall be designed in accordance with Section 2.6, *Geotechnical*.

Where foundation construction requires the use of drilled shafts and permanent casing, the foundation shall be constructed in accordance with the WSDOT *Construction Requirements for Light and Signal Standard Foundations Using Drilled Shaft Construction and Permanent Casing*.

*** determined during phase 1***

Where signal poles are mounted on structures, the structure mounts shall be designed in accordance with Section 2.13, *Bridges and Structures*.

2.21.3.4 *Junction Boxes, Pull Boxes, and Cable Vaults*

One pull box and one small cable vault shall be installed adjacent to and within 5 feet of each double-wide signal controller cabinet (Type 332D or Type 342LX). The pull box shall route conduit and signal conductors to the traffic signal side of the cabinet. The small cable vault shall route conduit and communication cables to the communication side of the cabinet. The pull box and small cable vault shall be labeled accordingly and there shall be no conduit connection between the pull box and the small cable vault.

2.21.3.5 *Wiring*

The Design-Builder shall follow the requirements of the WSDOT *Design Manual* and the following:

*** determined during phase 1***

2.21.3.6 *Signal Heads*

The Design-Builder shall use the following standards for signal heads:

- 12-inch signal lenses for all vehicle displays
- 16 by 18-inch lenses for all pedestrian displays
- Type *** determined during phase 1 *** mounting for all vehicle heads mounted on mast arms. Other signal mountings shall conform to the Standard Plans
- A minimum of one overhead display for each approach lane. Dedicated right-turn lanes may have the display mounted on the signal pole shaft in place of an overhead display.
- A minimum of 8 feet separation between all signal displays for a given approach
- Light-Emitting Diode signal heads shall be installed for all vehicle and pedestrian signal indications
- Pedestrian signal heads shall include a countdown timing feature
- All arrow displays for left or right turn signals shall be used for protected-only operations
- Flashing yellow arrow displays shall be used for permissive turning movements with dedicated lanes.

2.21.3.7 *Signal Standards*

The Design-Builder shall use the following standards for permanent signal standards:

- Signal standards with vehicle displays shall be Type I, Type II, or Type III standards. Type II and III signal standards may be single mast arm or dual mast arm. Dual mast arm signal standards shall only have mast arms oriented at 90 degrees from each other.
- Type PS pedestrian signal standards shall follow the guidelines of the WSDOT Design Manual when selecting fixed or slip bases.
- Type PPB posts shall be installed with a breakaway feature
- Type II and Type III signal standards shall have a terminal cabinet with two 12-position terminal blocks
- Signal standards that are not selected from the pre-approved list in the Special Provisions require a shop drawing and design calculation submittal in accordance with Standard Specification 9-29.6. All Type III signal standards shall only use Type 1 luminaire arms All signal standards shall be from the same manufacturer

- Type II and Type III signal standards and foundations shall be designed to support additional future wind load in accordance with the requirements of the WSDOT *Design Manual*
- A metal tag shall be permanently affixed to the top of foundation for each Type II, Type III, and special design signal standard indicating the foundation depth and diameter in accordance with Standard Plan J-26.15

Where pre-approved signal standards are not used, signal standards shall be designed in accordance with the requirements of the WSDOT *Standard Specifications* and Section 2.13, *Bridges and Structures*.

2.21.3.8 *Vehicle Detection*

Stop line vehicle detection shall be installed for all lanes including right turn and left turn lanes.

*** determined during phase 1***

2.21.3.9 *Traffic Signal Controller and Controller Cabinet Equipment*

*** determined during phase1 ***

2.21.4 *Construction Requirements*

2.21.4.1 *General*

The Design-Builder shall construct all components of a traffic signal system necessary to provide a complete and functional system that meets the requirements specified in this Section.

The Design-Builder shall perform all Quality Assurance and Quality Control testing for temporary and permanent signal systems in accordance with the Request for Proposal Special Provisions and Mandatory Standards. The Design-Builder shall incorporate the time required for traffic signal testing and turn-on, as described in this Section, into the Baseline Contract Schedule and Monthly Contract Schedule Updates for submittal to WSDOT. The Design-Builder shall submit all testing procedures, pass/fail requirements, and equipment documentation to WSDOT for Review and Comment and resolve all WSDOT comments a minimum of 14 Calendar Days prior to any testing. The Design-Builder shall submit test reports to WSDOT upon completion of each test in accordance with this Section and Section 2.28, *Quality Management Plan*. WSDOT may observe any tests and will audit test results. The Design-Builder shall notify WSDOT when all signal requirements have been met in accordance with the Contract, including training, documentation, testing, and field installations.

The WSDOT Engineer will perform the final electrical inspection and acceptance of traffic signal systems in accordance with WAC 296 46B, Electrical Safety Standards, Administration, and Installation.

The Design-Builder shall coordinate with the Utility Owner to determine the required separation between overhead Utilities and signal structures. The minimum separation between signal structures and equipment and overhead power lines, including the neutral, shall be 10 feet.

Signal cabinets and UPS cabinets installed with other cabinets shall be oriented so that the police panel and generator transfer switch are fully accessible.

Signal cabinets shall be installed with the front doors opening away from the intersection so that an engineer facing the front of the cabinet will also be facing the intersection.

All existing traffic systems, including the detection and preemption systems, shall remain in place and operational at all times. If any portion of the existing signal system will be removed or disabled, the Design-Builder shall provide and install temporary replacements for any removed or disabled equipment.

For temporary traffic signal installations, the Design-Builder shall install temporary detection for stop bar loop locations and advance loop locations prior to disconnection of existing detection. Downtime or fixed timing operation (no detection available) is not allowed without prior approval from the WSDOT Engineer and the WSDOT Signal Operations Engineer.

2.21.4.2 *WSDOT Electrical Inspector*

The Washington State Department of Labor and Industries has authority over all electrical installations within the State. WSDOT has been granted authority over all electrical installations within the Right of Way of State highways, provided WSDOT maintains and enforces an equal, higher, or better standard of construction, materials, devices, appliances, and equipment than is required by Applicable Laws. It is the role of the WSDOT Electrical Inspector to ensure that all electrical installations, including Illumination, Traffic Signal, and ITS installations, meet the requirements of the National Electric Code, and Applicable Laws and provisions.

The WSDOT Electrical Inspector will perform the following:

- Act as a resource for the electrical design team
- Assist with electrical system plan reviews (as applicable)
- Perform periodic electrical inspections during construction
- Witness required field tests (as desired)
- Perform inspections required before energizing any new equipment or circuits
- Inspect and approve all electrical installations in accordance with this Contract.

2.21.4.3 *Operation and Maintenance*

Upon Notice to Proceed, the Design-Builder shall be responsible for maintaining all traffic signal system equipment outside of the controller cabinet, up to and including the landing of field wiring in the controller cabinet, for all traffic signal systems identified for modification or removal. The Design-Builder shall retain this maintenance responsibility until Physical Completion of the Project. WSDOT Region Traffic Signal Maintenance Staff shall retain maintenance responsibility for the equipment inside the traffic signal controller cabinet.

As part of maintenance responsibility, the Design-Builder shall be responsible for performing locates for all traffic signal systems included in the Work. WSDOT will perform the first set of locates requested by the Design-Builder for existing systems – refresh requests are the responsibility of the Design-Builder.

The Design-Builder shall be responsible for repairs to the WSDOT Engineer's satisfaction and at no cost to WSDOT, any damage caused by the Design-Builder to traffic signal systems. The Design-Builder shall take all necessary actions to ensure safe operation of the intersection. If the Design-Builder's Work impacts the operations of an existing traffic signal, the Design-Builder shall immediately rectify the impact and resume the operation of the impacted signal. Liquidated damages will be assessed for unplanned signal system disruptions lasting more than 24 hours. Refer to Section 1-08.9 of the *General Provisions*.

The Design-Builder shall remove all temporary signal system installations if any, after the new permanent signal systems are completed and operational.

The Design-Builder is not authorized to program or operate any traffic signal system controller. Only WSDOT staff may program or operate a traffic signal controller, including placing a system into or out of flashing operations using the police panel. WSDOT staff authorized by the Region Signal Maintenance Manager, which may include WSDOT Engineer assistants and inspectors, may access the police panel and place a system into or out of flashing operations in coordination with the Design-Builder's Traffic Control Supervisor in support of traffic control operations.

2.21.4.3.1 Emergency Maintenance

The Design-Builder shall notify the Traffic Systems Management Center and the WSDOT Engineer in the event that a situation related to public safety is observed, such as a dark or flashing signal intersection, improper signal timing, misaligned signal heads, exposed wires, or knockdowns.

For systems included in the project, the Design-Builder shall perform all required emergency repairs on equipment outside of the traffic signal controller cabinet, up to and including the landing of field wiring in the controller cabinet. Repairs or temporary replacements shall be installed and operational within 8 hours of initial notification of a fault.

WSDOT Region Traffic Signal Maintenance Staff will respond for repairs to equipment inside the traffic signal controller cabinet.

2.21.4.4 *Permits*

When a Traffic Signal Permit is required, the Design-Builder shall prepare and submit the traffic signal permit application in accordance with Chapter 1330 of the WSDOT *Design Manual*. The Design-Builder shall also provide supplemental information as described in Section 6-3 of the WSDOT *Traffic Manual*. No traffic signal construction may occur without an approved Traffic Signal permit. Modifications to existing WSDOT maintained traffic signals will require a traffic signal permit for a report of change.

2.21.4.5 *Testing and Turn-On*

The Design-Builder shall satisfy the requirements of Section 8-20.3(11)A of the Standard Specifications and document completion in accordance with the WSDOT *Signal Turn-On Requirements.* The Design-Builder shall submit the Signal Turn-On Checklist to the WSDOT Engineer for Review and Comment 5 Calendar Days prior to scheduling a turn-on date for that traffic signal system. Turn-On shall be in accordance with Section 8-20.3(11)B of the Standard Specifications.

$$1$$

2.21.4.6 *Material Requirements*

The Design-Builder shall furnish and install all materials required for revisions to the existing traffic signal systems.

No traffic signal materials will be provided by WSDOT for the Project.

Materials shall meet the requirements specified in Section 9-29 of the Standard Specifications, and as supplemented and amended by this Section and the Special Provisions.

2.21.4.7 *Salvage*

The Design-Builder shall salvage existing traffic signal equipment removed by the Design-Builder as described in this section.

The following traffic signal equipment shall be salvaged and delivered to the agency designated:

- *** determined during phase 1***

Salvaged equipment shall be delivered to the applicable address below:

*** determined during phase 1***

Fourteen Calendar Days prior to delivery of salvaged items, the Design-Builder shall provide a list of salvage items, their quantity, and their current condition to

the WSDOT Region Signal Maintenance Superintendent or applicable agency contact. The Design-Builder shall give a minimum of 7 Calendar Days' notice to the WSDOT Region Signal Maintenance Superintendent or applicable agency contact prior to delivery of salvaged equipment. The Design-Builder shall provide all labor and equipment to transport, load, and unload the salvaged equipment.

2.21.4.8 *Temporary Signals and Temporary Modifications*

Temporary signal system(s) and temporary modifications to existing signal systems shall be designed and installed when required in accordance with this Section and Section 2.22, *Maintenance of Traffic*. Temporary signal systems shall be modified, adjusted, or relocated as necessary to accommodate the Released for Construction (RFC) Traffic Control Plans, Staging Plans, order of Work, and detours. After the permanent signal system is energized and made operational, or restored to original configuration and operation, the temporary signal system and/or temporary modifications shall be completely removed. All temporary system poles, wiring, junction boxes, conduit sweeps, and cabinets shall be removed. Holes and voids shall be backfilled.

Temporary signal systems and temporary modifications to existing signal systems shall meet all requirements for permanent traffic signal systems.

2.21.5 *Submittals*

All deliverables shall be in accordance with the requirements of Sections 2.12, *Project Documentation*, and 2.28*, Quality Management Plan*.

The Design-Builder shall also submit the following back-up data items with the Preliminary Design Submittal:

- Speed study data indicating 90th, 85th, and 10th percentile speeds for all approaches
- Peak hour turning movement counts (a.m., midday, and p.m.)
- Detection zone placement calculations in accordance with the WSDOT *Design Manual* Phasing analysis to support protected or protected-permitted left-turn phasing. If protected-permitted left-turn phasing is planned, provide verification that conditions are suitable for this type of operation.
- A1 height calculations for proposed and future phasing to verify minimum/maximum allowed roadway clearances. Attach cross sections for review.
- In the case of temporary span wire installations, calculations and cross sections are required to verify that roadway clearances will be within the allowable range.

The Design-Builder shall also submit the following back-up data items with the Final Design Submittal:

- Wind load calculations for signal mast arms for proposed and future phasing conditions to support foundation sizing. Attach soils analysis for each signal standard to verify foundation design. Attach back-up design data for all special designs. In the case of temporary span wire installations, strain pole class and foundation selection calculations are required to support the design.
- Electrical load calculations in accordance with Section 2.16.3.5.3, unless these calculations are already included in submittals for Section 2.16, *Illumination*.
- Utility Agreement and Utility Relocation Requests
- Conduit fill and junction box capacity calculations

The Design-Builder shall submit a Signal Turn-On Checklist to the WSDOT Engineer for Review and Comment 5 Calendar Days prior to placing any new or modified traffic signal into operation.

2.21.5.1 *Working Drawings*

Working Drawings and product data shall include the following:

- Shop drawings for all poles, mast arms (by type and size), and pedestals
- Service cabinets
- Luminaires and lamps
- Ballasts and photoelectric controls
- Paint (prime and finish)
- Fuse holder kits, fuses, and insulating boots
- Loop detector splice kits
- Vehicle signal indications and lenses
- Pedestrian signal indications, lenses, and housings
- Emergency vehicle preemption equipment
- Video detection equipment

2.21.5.2 *Preliminary Signal Plan*

The Preliminary Signal Plans shall be prepared in accordance with the Mandatory Standards. The Plans shall include, at a minimum, the following items:

- Plan showing location of signal standards; controller cabinets; detection zones, loops, or both; detector locations; conduit; and junction boxes required for the installation
- Signal sequence/phasing diagram
- Identification of existing signal items to remain
- Title block, north arrow, and scale bar
- Legend of symbols

- Existing signal features and Utilities
- Proposed channelization
- Illumination
- Signals to be interconnected
- Cabinet locations and orientations

The Design-Builder shall submit the Preliminary Signal Plans to the WSDOT Engineer for Review and Comment as part of the Preliminary Design Submittal.

2.21.5.3 *Final Signal Plan*

Permanent Signal Plans shall be complete and include, at a minimum, all the items from the Preliminary Signal Plan Submittal and the following:

- Conduit and conductor schedule showing new wire and existing wire to remain
- Field wiring diagram and cabinet wiring termination diagram for each signal system
- Complete construction notes
- All wire, cable, and terminations that are needed for the complete operation of the signal system
- Pole schedule specifying mounting height, attachment offsets, attachment angles, and foundation depths
- Cabinet input file detail sheet
- All references to Standard Plans and electrical details
- Structural calculations
- All signal details in accordance with, at a minimum, the WSDOT ***$$1$$*** *Illumination and Signal Details*
- Pull box, cable vault, and junction box locations and details
- Interconnect Plans and details including cabinet electronics, wiring, and equipment installation
- Loop termination schedule
- Cabinet and pole foundation details
- Details for non-standard elements
- Radar or IR Video detection system (including detector(s), mounting hardware, cabling, and installation details)
- Wire notes (including identification of new and existing conductors, cable, and conduit)
- List/quantity of items to be salvaged
- Documentation regarding the power source and coordination with the local power company

- Design Documentation (such as clearance measures, loop test sheets, voltage drops, and conduit fill calculations)

2.21.5.4 *Released for Construction Documents*

The Design-Builder shall include the following items with the Released for Construction Documents:

- All elements required for the final signal design
- All resolved comments from the final signal design
- Additional design elements addressed

2.21.5.5 *Miscellaneous Submittals*

At the request of the WSDOT Engineer, the Design-Builder shall deliver to the WSDOT Engineer Work related submittals that do not fit in the previous categories but are prepared in accordance with this Section.

End of Section